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# Architectural Framework to Preserve Information of Cardiac Valve Control

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**Abstract**—According to the relation of Digital Preservation and the Health field as a case of study, the architectural model help us to explain that definitions. The principal goal of Data Preservation is to keep information for a long term. Regarding of Medical information, in order to perform a heart transplant, physicians need to preserve this organ in an adequate way.

This approach between the two perspectives, the medical and the technological allow to check the similarities about the concepts of preservation. Digital preservation and medical advances are related in the same level as knowledge improvement.

## I. BACKGROUND

Normally, one preservation method is to place the organ into a refrigerator, considering that low temperature between 40C to 0C is the optimum and that the organ can be outside the body from 4 to 6 hours. However, this method is not adequate due to it does not allow physicians to evaluate the conditions of the heart during the transportation towards the patient.

It generates several inconveniences that physicians have to deal with. According to the latest research it is possible to extend the period of preservation up to 12 hours, which represents a relevant progress. Although it has been tested in a pig's heart, the method promises good results and it could allow transportation of the organ over long distance. It would result that people who live in other cities or countries, can receive their transplant. This project will simulate heart's valves in order to analyze their behavior and maintain updated information of the organ. To display the relevant information, software with all the main important parameters of the heart will be used. It would help the physicians to make sure that the organ complies with all the requirements to be used for the patient and modify the process if it is necessary.

This document provides a brief but clear explanation about the heart, its main parts, its main function in the human body, and the methods for its preservation. Furthermore, a description of a possible method to simulate the control of heart' valves is explained as well. Heart transplantation has been performed over many years and over time the procedures have also improved. According to new research, it is possible to preserve this organ from 4 to 6 hours using a regular method called Simple Cold Storage. However, this method is limited by physicians monitoring all vital signs of this organ. At the

Alfred hospital, which is the pioneer in heart transplants in Australia, research has been proposed to extend the duration of preservation.

+This procedure would allow more time to transport the organ over long distances until it reaches its final destination, the patient. According to physicians, this could be done by setting the heart in a stand-by mode. This means that the metabolism of the organ is turned down and reactivated when this be ready to be transplanted. During this period, doctors need to obtain information about the heart, if it still performing all functions and that everything is will be fine when it is reactivated. Based on the information described above, the aim of this project is to simulate a system for controlling and monitoring the valve of the heart. This procedure will simulate the standby mode, which is used in the real heart transplant. It will allow verifying and having an idea how the organ will get to the patient. Furthermore, software that allow us to visualize the vital signs will be used. It will benefit doctors to control the whole process and take actions if something happens in the process.

## A. CLINICAL BACKGROUND

### A. The heart

This is an organ that is formed by 4 chambers which are located in the left of the thoracic cavity. These 4 chambers are divided by 2 upper chambers called atria and 2 lower chambers called ventricles. Between each atrium and ventricle, valves allow blood to flow in one direction, preventing backflow. The blood has low concentration of oxygen and it flows into the right atrium from the veins. These veins are known as the superior vena cava and inferior vena.[1]

### B. Structures of the heart

The heart is situated in a fibroserous double wall called The pericardial sac is divided into 2 parts: serous pericardium and pericardium. Serous pericardium is constituted by 2 layers which are visceral and parental. The function of this layers is prevent contact among the heart and the pericardium. Moreover, the heart is constituted by 4 main valves: pulmonary valve, mitral valve, tricuspid valve, and aortic valve. - Pulmonary valve is located at the entrance to pulmonary

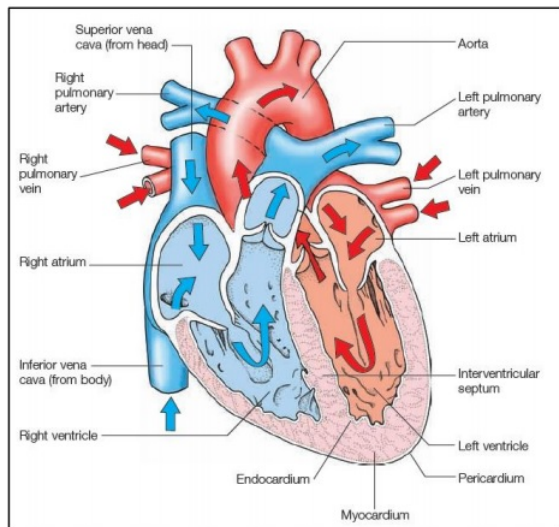


Fig. 1: Figure 1 Blow through the heart [1]

trunk. The aim of this valve is to allow blood to move from pulmonary trunk into right ventricle when the ventricular relaxation occurs. –Mitral valve: It is located between left atrium and left ventricle.

The main function of this valve is to prevent that blood moves from aorta to the left ventricle when the ventricular relaxation occurs. [2] –Tricuspid valve: This valve is found between right atrium and right ventricle. The principal function is that during the ventricular contraction, it prevents that blood flows from right ventricle to right atrium. - Aortic valve: It is located in the entrance to aorta. It avoids that blood flows from aorta into left ventricle.

### C. Dimensions

The size of the heart depends on two factors: the weight and the amount of blood. Normally, the size of the heart corresponds to the size of the fist of the person. The weight of the heart in a healthy adult is about 300-350g. This represents the 0.5% of the body[3]. Furthermore, it is important to mention that the heart under physiological conditions depends on body weight, age, sex and physical training.

### D. Blood supply to the heart:

The heart obtains blood supply from the right and left coronary arteries. Normally, the size of the coronary artery is bigger than the left.

### E. Heart preservation method

Over many years, it has been important to develop methods to preserve organs. These methods of preservation have helped people to receive an organ transplant and have a normal life. Furthermore, the preservation provides the time needed to identify the right recipient based on immunological tissue matching, size of organ and urgency of need for the transplant.[5]

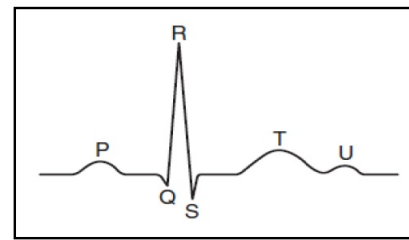


Fig. 2: ECG waves [6]

1. *Simple cold storage*: In this method, the organ is placed in a suitable solution to eliminate blood elements and to cool the organ. The range of temperature of the solution is between 0 to 4°C. The importance of this method is because it is possible to cool the organ from 37°C to 0°C or 4°C. The low temperature allows preserving the organ in a better way. Comparing with warm ischemia, the organ loses viability in just a couple of hours due to the lack of oxygen and perfusion.

2. *Continuous machine perfusion*: In this method, the temperature is maintained in the range of 4°C to -6°C. Comparing with the simple cold storage method, the delayed graft function is less, which constitutes an important feature. This characteristic can help to determine which method is better to preserve the organ such as kidney, liver, heart, pancreas, and lung. For instance, lung and pancreas can be preserved without continuous perfusion. However, the continuous delivery of oxygen to the organ maintains the ATP (adenosine triphosphate) and provides protection against the ischemia state. [5]

3. *Future of organ preservation*: The main goal of this field is to develop a method to preserve the organ up to 6 hours. Currently, it has been difficult to develop a method to preserve the organ for many hours. The reason is because the organs need a source of energy to avoid destroying the tissue. Energy needs to be present constantly in the tissues and cells. If this doesn't occur, membranes, cell interaction, and complex molecular structures could deteriorate.

### F. The electricity of the heart

The contraction of any muscle normally is associated with electrical changes called depolarization. These changes are identified using electrodes that are attached to the surface of the body. It is important to mention that to measure this activity, the patient must be relaxed without showing any skeletal contraction.[6]

This device shows 6 features of the wave named P, Q, R, S, T, and U. The P wave is associated with the contraction of the atria. When the ventricles are depolarized, there is a large deflection called QRS. The T wave is associated with the repolarization state, which is the return of the ventricular mass[6]. All these changes can be observed in the next figure.

### G. Heart-Lung machine

Basically, this machine is made of a motor which pumps the oxygenated blood into the arteries of a patient at a low

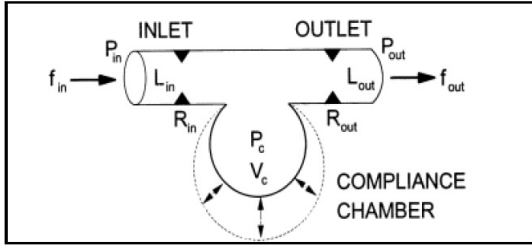


Fig. 3: Idealized segment of artery

rate equivalent to that normally pumped by the heart. [7]. The oxygenator removes the carbon dioxide and adds oxygen to the blood, which is the typical function of the lungs. After this process, the machine continues by pumping the oxygenated blood back to the body. This process is achieved by several tubes that are connect to the patient. When the operation finishes, the surgeon gradually lets the patient's heart return to its normal function. [8]

## II. CARDIOVASCULAR ENGINEERING

Cardiovascular engineering is a field that includes sub-field such as: physiology, cell and molecular biology, biomechanics, and bioelectricity. This field was created to understand the behavior of the cardiovascular system. Basically, the main goal of this field is to test and develop predictive systems that allow us to understand the behavior of the systems from an engineering view and to apply solutions to improve the people lifestyles.

### A. Cardiovascular Modeling

1. *Modeling an artery* : In order to model a cardiovascular system, we need to consider the basic element of the heart which is the artery. A segment of artery can be modeled by an elastic, isobaric chamber attached to a rigid inlet. Mathematically, it can be defined as:

$$C = \frac{dV_c}{dP_c} \quad (1)$$

$V_c$  represents the total segment of pressure of the chamber and  $P_c$  is chamber pressure.

To model this part using electronic elements, it is possible to use the three principal components: inductance, resistor, and a capacitor. Taking into account the figure showed above, the electrical model of an artery is:

### 2. Modelling a vein

In most venous circulation, the pressure inside the vessels is greater than the external pressure. But three specials considerations exist when we model a vein. The first condition occurs when the inlet and outlet pressures are positive. The second condition is when the inlet and outlet pressures are negative. The third condition occurs when the pressures are changed between the inlet and outlet pressures. In other words the inlet pressure is positive and the outlet pressure is negative. When this occurs, blood flows into the chamber and produces

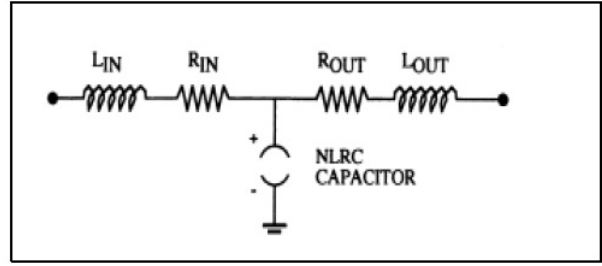


Fig. 4: The idealized segment of artery using an RLC circuit [10]

a pressure rise inside. This opens the outlet and allows the blood flow out.

### 3. Arterial and Venous trees.

To model a vessel, it is possible to use the output of one segment as the input to a second, and the output of the second as the input to a third and so on. Using differential equations allows modelling arbitrary lengths of vessels. Furthermore, this method allows that adding of a bifurcation. Basically, the first step to do this is to formulate partial differential equations to define the flow in the vessel. After this, these equations are replaced by finite differences. This model can be represented using resistors and inductances. However, it is important to take into account that to avoid problems due to the impedances it is necessary to add intermediate segments to match these between the heart and the capillaries.

## III. CARDIOVASCULAR BIOMATERIALS

Biomaterials are any substance[11]es or combination of substances that can be synthetic or natural which can be used for a period of time and can replaces a tissue, organ, or function of the body. Cardiovascular biomaterials are used in two modes: temporary and permanent. According to these modes, cardiovascular devices can be classified as temporary internal, temporary external, and permanent internal devices. Considering these materials are in contact with the blood, their duration may be limited[12]. One of the causes of biomaterial failure is the initiation of thrombosis in the blood. This can occlude the device or can occlude small blood cells[11]

### A. Classification of cardiovascular biomaterials

Biomaterials can be classified in: metals and their alloys, polymers, and biological materials.

1. *Metals and alloys*: Normally the metals are used in applications such as: heart valves, endovascular stents, and stent-graft combination. The most common alloys used are: SS(stainless steel), Co-Cr(cobalt-chrome), Ta(tantalum), etc.

2. *Polymers*: These materials are very common in cardiovascular applications. For instance, prosthetic heart valves, catheters, hemodialyser, etc.

3. *Biological materials*: Most of the commercially devices are made of collagen. This material is a macromolecule that exist as a triple helical of several amino acids.[11]

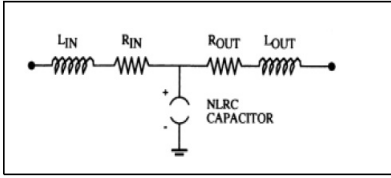


Fig. 5: Conventional voltage-mode instrumentation using three operational amplifiers [14]

### B. Biocompatibility

In order to see if the material that is going to be used in the medical device complies with all the requirements, a test must be performed. This test have to consider the effects of the material in blood . To do this, international standards are taken as a reference. These standards describe the series of test and the selection of the material according to the time that the device will be in contact with the body either this device be internal or external. The cost of performing these tests is significant, but screening test can be performed on any new material. These tests are a subdivision of the standard tests. Some materials manufacturers provide biocompatibility data of this type. [11]

## IV. SIGNAL ANALYSIS AND VALVE CONTROL

In order to design the project and meet the goals, the project can be divided in 2 main stages. The first stage is the signal analysis and the second one is the valve control. Moreover, the first stage can be subdivided in 4 stages: Signal acquisition, signal conditioning, signal processing, and signal analysis.

### A. Signal Analysis

1. *Signal Acquisition* : To measure a physical phenomenon and convert the measured parameters into electrical signal to be used in the next stages, it is necessary to select the right sensor to acquire the information required by the clinicians. In this case, the possible sensors to collect information could be a disposable pressure transducer.

2. *Signal Conditioning* : In this stage the information is manipulated to meet the requirement for further processing. To condition the signal, it is possible to use operational amplifiers. It is important to take into account that we can to use instrumentation amplifiers. The main reason is that with this configuration it is possible to adjust the signal according to the specifications.

3. *Signal Conditioning* : In this stage, the signal is converted from analog to digital form in order to get the information. To avoid issues, a DAQ which is a card created by National Instruments, will be used. This electronic device allows collecting information for any kind of sensors. In order to do this, the terminals of the sensors are connected to the A/D channels of the card.

4. *Signal Analysis* : In this stage, information is stored and interpreted by physicians. The interpretation will allow them to know if the organ is meeting with all requirements. To display the information of the organ, LabVIEW software will be used

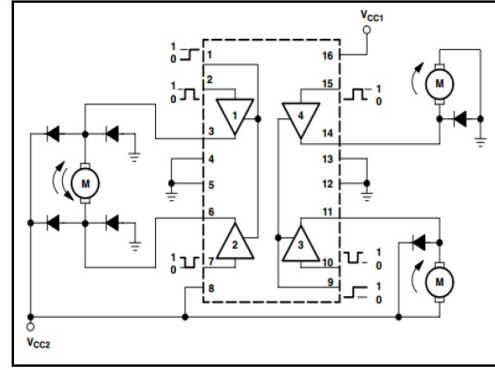


Fig. 6: L293D Internal circuit

due to the ease of programming and the advantages that this has. For instance, using a preprogrammed block it is easy to recognize the DAQ to collect information from the sensors and display them on the screen.

## V. METHODOLOGY

In order to develop this simulator, it is necessary to establish a methodology that allows achieving all the goals. The first step is controlling the motor of the valves. In this particular case is necessary consider two important parameters: current and voltage. These parameters will determine what kind of transistors and electronic devices we will use to perform this control. Analyzing the motor, it was possible to determine that the integrated circuit L293D can drive the necessary current to control the motor.

Basically, this integrated circuit is a buffer. This means that this element can drive current, which is an important parameter for our case. Furthermore, the integrated circuit allows us perform PWM. One of the advantages to use this IC (integrated circuit) is that we avoid calculating the values of the transistors and resistances to build an H-bridge. On the other hand, to control the valve we need to get the information from the pressure sensor. In this particular case, it will be acquired using a DAQ. This card allows collecting information from different sensors and showing this on the screen. This DAQ is composed of digital and analog inputs. The big advantage of this device is the compatibility with LabVIEW. This software permits creating programs called virtual instruments because their appearance and operation imitates physical instruments such as oscilloscopes, multimeters, signal generators, etc. LabVIEW has a comprehensive set of tools for acquiring, analyzing, displaying, and storing data. [15]

## VI. PROCESS MODELLING

Preservation strategies and the use of software tools for emulation or migration must always be chosen in reference to requirements of institutions. The applicability of both strategies are context dependent. It is related with the complexity of the analysis. One possibility to support such decision processes are software tools which accomplish full traceability and documentation of the final result. Once the alternative and

the preservation paths are specified, the experiments could be proved. Then the analysis of the utility has to be integrated in inhomogeneous criteria, like cases of study for evaluating different strategies. The framework is often a layered structure indicating what kind of relations can or should be built and how they would interrelate.

The accessibility and the categorisation of filtering information is related with the state of 'The evaluation of a given data set is based upon inputs from three components: the Maturity Matrix, Data Set Activity levels, and Stakeholder Input'. [17] Furthermore, 'Clustering and association analysis are important techniques for analyzing data. Cluster analysis provides insight into the data by dividing the objects into groups (clusters) of objects, such that objects in a cluster are more similar to each other than to objects in other clusters.' [18] It seems to be a good application of clustering and how to classified. A further motivation is also to provide the convenient way to search the information.

There are two considerations in this part:

- Physical (access) and Cognitive (contextualization).

Other issue that we have to consider is the management of the artefacts in terms of preservation. Nowadays the requirements of useful storage should be enough in terms of technology, but the specific classification of the information with criteria without losing the original knowledge is the real challenge in the intelligent and efficient preservation. The objective for understanding the perspective throughout the development process has been for building the basement concepts and knowledge.

The user requirements involved the authenticity and reliability of the knowledge information. The needs in storage media, migration, conversion, emulation and management strategies have been focused as a consequence of the appropriate implementation of the Framework, Methodology and Patterns. In fact the organization of the strategy is important. Additional research in these areas would help digitalization developers with preservation responsibilities for integrating long-term preservation into planning, administration, system architectures and resource allocation.

Consequently it is a challenge to identify metadata and classify them while the conventional solutions have been very limited. The investigation of scalable solution with the identification of metadata and emphasize the role of methodology and patterns should be useful to provide guidelines for protecting resources from dealing with obsolescence, responsibilities, methods of preservation, cost, and metadata formats. Based on the experience of National Library of Australia, the principal factor that we have to consider in the application of preservation is to provide frameworks related to digital heritage. It is one of cases of study and applications basically with the use of archives. The objective for understanding the perspective throughout the development process has been for building the basement concepts.

Knowledge Preservation has been applied in many areas focus on including; standards, scalable designing, adaptive and survivable network applications. The users and custodians

require integrating two basic concepts in terms of preservation: authenticity and reliability.

The differentiation The needs in storage media, migration, conversion, and overall management strategies have been focused as a consequence of the appropriate implementation of the Framework, Methodology and Patterns. Additional research in these areas would help digitalization developers with preservation responsibilities for integrating long-term preservation into planning, administration, system architectures and resource allocation.

The main topic is related to the preservation and management. The research questions are related with the integrity and authenticity of the information we manage. The methodology specified the way I can join the ideas of preservation. This concept of management of information is very important. This article deals with the concepts of preservation. This is directly relevant to my research because my topic is about Data preservation like the central concept of this Research.

Research by Chandras [16] explains the relationship between the terms for preservation and genetics. Nowadays Biological databases are useful for determining the interaction of biological molecules and process. The financial issues known as the important matters for evaluation of the preservation patterns is useful for testing the methodology presented. The web data concept and the use of data warehouse are the principal tendency for the management of information.

The behaviour of BRC Biological Resource Center reflects the best approximation of the concepts. In the context of the studies of the maintaining Data Records [17]. 'An operational climate data service must ensure that all climate data are preserved and made available to users. In addition to the climate data; metadata; production software source code; documentation on the data, metadata and data formats; calibration/validation information; and QA information will also be archived.

Regular backup of data and the capability to migrate any or all of this information to new media are also important.' The challenges are specialized for deciding to manage the data sets that have to be measured. The activity to generate information and in different types and also integrate the quality for the three dimensions impact.

Otherwise, the patterns are related with this terminology. On the other hand using the Open Group Architectural Framework (TOGAF) [19] the research should base the central part in developing of Standardised Framework.

Although it can also be used for other purposes such as comparing file formats or evaluating the performance of conversion applications the best of this technique is Collecting Data for having only one parameter. Metadata conceptualization plays an important role in preservation of digital heritage and archives in the digital objects. The quality as one of the principal issue should be considered like a summary of good authenticity and good reliability. However, as digital objects evolve over time, their associated metadata evolves a consistency issue. Since various functionalities of applications containing digital objects (e.g., digital library, public image



Performance and Scalability	Dependability	Manageability	Data Access
Data Ingest	High Availability	Management Tools	File System Access
Metadata	MapReduce HA	Volume Support	File I/O
Architecture			
Database	Upgrading	Alerts	Security ACLs
Performance			
Applications	Replication	Integration	Wire- Level Authentication
	Snapshots	Data and Job Placement Control	
	Disaster Recovery		

TABLE I: Quality Attributes: Lucia Carrion 2014

repository) are based on metadata, evolving metadata directly affects the quality of such applications. Modern data applications are often large scale (having millions of digital objects) and are constructed by software agents.

#### A. Quality Attributes

The quality attributes and the approaches around Digital Data Preservation are:

- 1) Performance and Scalability
- 2) Dependability
- 3) Manageability
- 4) Data Access

For the formulation of the Hypothesis the relation between keywords and statements is important consideration for improvement of the proposal model.

*The relation between Software Architecture and Serendipitous Heritage is going to improve Data Preservation Heritage oriented metadata for improving the real usage of the information.*

The inclusion of Serendipitous Heritage improves performance, scalability, dependability, manageability and data access for Digital Data Preservation Mechanisms in Big Data Architectural solutions. The important knowledge, exactly the context situation relationship and concept. The best way is to demonstrate, validate and show the benefits. The mankind do different activities, how well the Serendipitous Heritage concept will help to grow the meaning of Data in every field.

The massive amount of data and the growth of Big Data drive the society to preserve the information principally related with the lost of key information. The protagonism in the role of metadata and the requirement that data has to be kept in a long term open the alternative to focus on information management.

### VII. ARCHITECTURAL FRAMEWORK

Introduce a consolidated, systematic approach to the re-design of a business enterprise. The methodology includes the five activities:

- Prepare for reengineering,
- Map and Analyse As-Is process,
- Design To-be process,
- Implement reengineered process
- Improve continuously

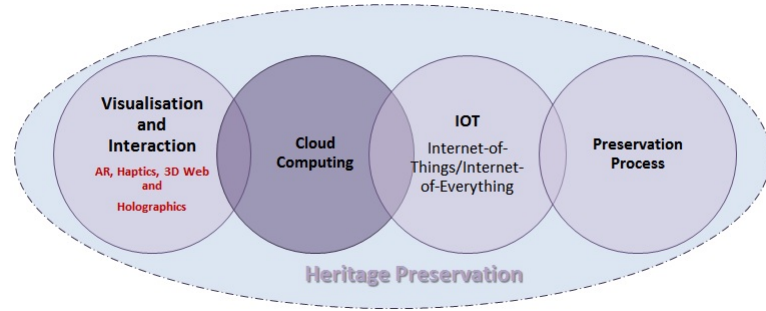


Fig. 7: Computer Processing

### VIII. CONCLUSIONS

- The context, relation and situation of Heritage are impressive relevant in the research because it gives the sense of the future of the Knowledge in the World. Through medical process of Preservation will do a contribution for society advances.
- Outlined, heart transplants have been performed for many years and over time the procedures have improved. A few years ago it was possible to preserve the heart for 6 hours. However, using a new combination in the fluids that are supplied to the heart, it is possible to preserve this organ for almost 12 hours. Preservation in context of medical issues and technological approach has incidence.
- This new discovery could allow transporting the organ over long distances and help more people to receive their heart transplant. Basically, the aim is to design a physical system that simulate the process of preservation of the heart. The idea is to implement this system into the principal heart-lung machine, which is used to perform this process. Heritage Preservation is Oriented to have the process recorded.

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